LAND COVER CHANGE PROBLEM: LESSON: VEGATATIVE CHANGE DETECTION USING Δ NORMALIZED DIFFERENCE VEGETATION INDEX IMAGE (ΔNDVI)

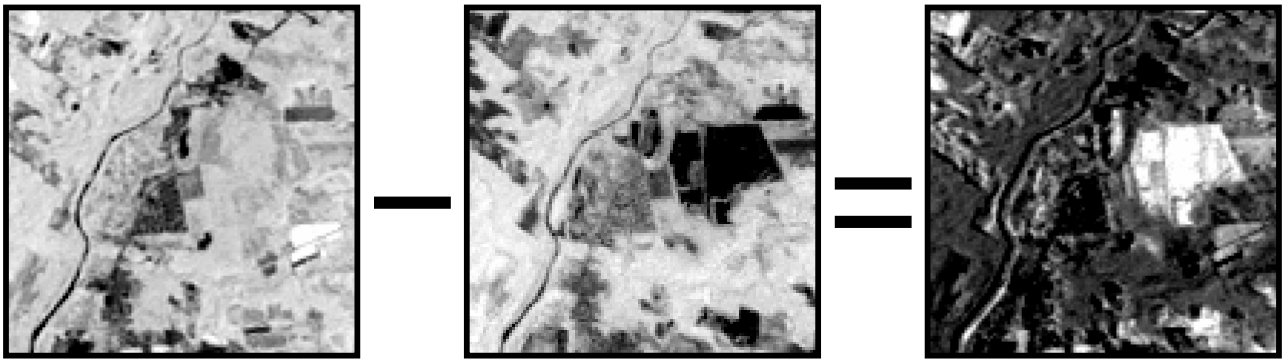
Intermediate-Advanced Level

Purpose

To identify land cover change using the ΔNDVI images

Overview

The ΔNDVI image clearly shows the areas of vegetation loss in the period between the two images. In the below figure, VCD Figure 1, the resulting ΔNDVI image shows where areas of vegetation loss are bright (white.) In this example the selected area is a landfill and a gravel pit on the western shore in Maryland.

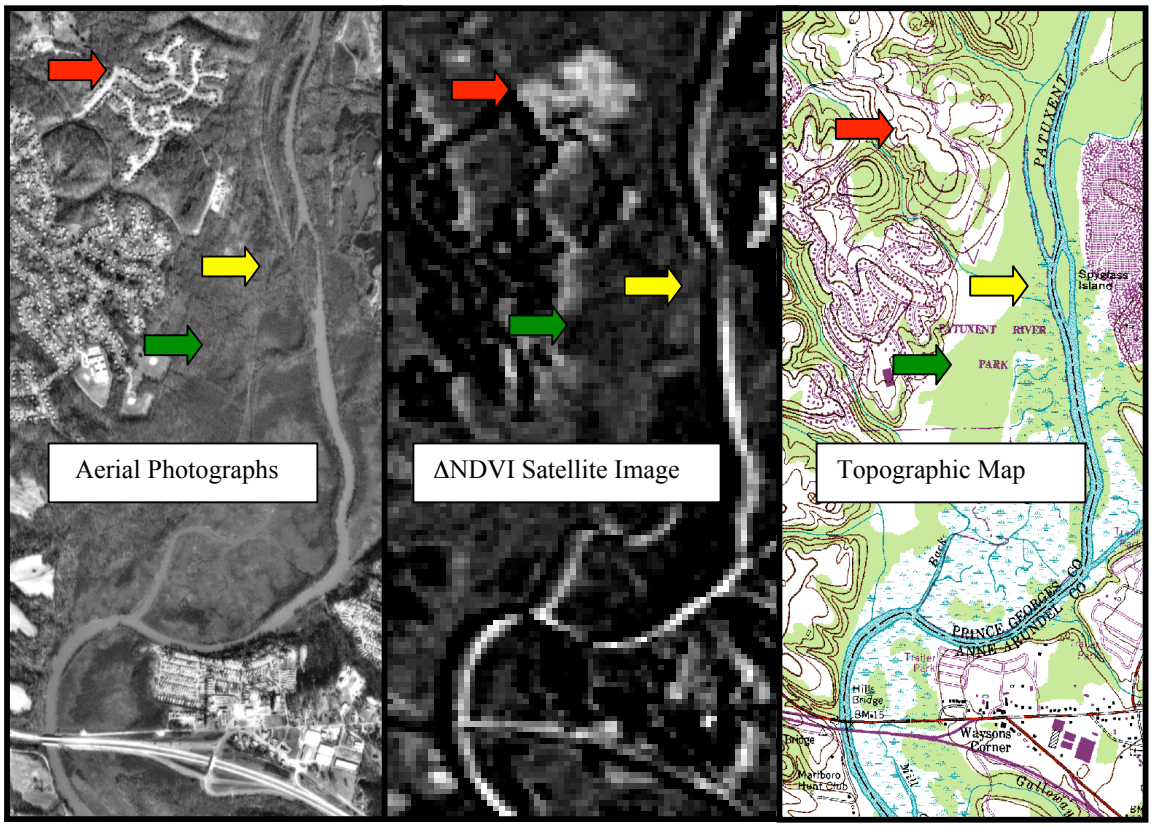


1984 NDVI (C1) **1997 NDVI (C2)** **ΔNDVI**

VCD Figure 1.

The students can investigate vegetation loss and patterns of change in a given time period. The following diagrams, VCD Figure 2, display how students can use ancillary data- topographic maps and aerial photographs to help identify the ΔNDVI image. This lesson offers students an excellent opportunity to solve problems in small groups. They can manually interpret the ΔNDVI image using topographic maps and aerial photographs. Figure VCD 2 illustrates what students will see when they compare these data sets. In this comparative set of images numerous land cover features can be identified using the aerial photograph and the topographic map. A new residential development can be seen next to the red arrow. We know that this was developed after 1984 due to the high ΔNDVI value for this same area. This interpretation ΔNDVI image is greatly improved by conducting the ***Science Lesson: Aerial Photograph Interpretation*** prior to this lesson.

The ΔNDVI image allows students to visualize the changes between vegetative land cover in two different satellite images of the same area taken at different times. The two images used will be determined by availability. Theoretically, if students wanted to study the changes in their local community they could create ΔNDVI images that display long-term changes or short-term changes. The current plan is to release seasonal scenes to schools that are collecting and entering data.



VCD Figure 2. The above set of images and maps illustrates how different data sets can work together to aid in the interpretation of the ΔNDVI image. In the selected area, a section of the Patuxent River, there are three different features that can be easily identified using the aerial photograph.

The above three images are similar to those that could be used to study the local area through using remote sensing techniques. The aerial photograph and topographic map are used to locate and identify the areas of change in the ΔNDVI image. For this lesson students will use Prince George's county Maryland data sets to identify areas of change and determine possible causes of the changes over time. Once identified, students can discuss how the land cover changes might impact the community and the area's flora and fauna.

Time

- 3-4 class periods to interpret the ΔNDVI images.
- Time out of class can be used for the data analysis.
- Advanced level may take longer by a day or two.

Level

Intermediate and Advanced

Key Concept

Communication skills

Read and understand images produced by others

Produce images for other to interpret **(Advanced only)**

Find and describe locations on maps and computer-generated images

Technology/Software Mastery

Use computer software to generate images

Use computer software to scale images **(Advanced only)**

Use computer software to interpret image **(Advanced only)**

Bench Marks

11D As the complexity of any system increases, gaining an understanding of it depends increasingly

On summaries, such as averages and ranges, and on descriptions off typical examples of that

system.

12A Values and Attitudes

Know why it is important in science to keep honest, clear and accurate records

Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.

Know that often-different explanations can be given for the same evidence, and it is not always possible to tell which one is correct.

12B Computation and Estimation

Use, interpret, and compare numbers

Estimate distances from maps and actual sizes of objects from scale drawings

Decide what degree of precision is adequate

12E Critical-Response

Be aware that there may be more than one good way to interpret a given set of findings

Be skeptical of arguments based on very small samples of data, biased samples or samples for which there is no control sample

Skills

Identifying images
Managing time
Collecting data
Integrating information
Analyzing data
Interpreting data to make a decision
Drawing conclusions
Reading and map interpretation
Using computers
Solve Problems in a group setting
Critically discuss issues and procedures

Materials and Tools

- MultiSpec software
- Landsat color composite images:

QASAUG84 chs. 321	QASAUG84 chs432	QASAUG84 chs542	84 NDVI	
QASJUL97 chs321	QASJUL97 chs432	QASJUL97 chs542	97 NDVI	8497ΔNDVI

- NAPP Aerial photographs:

Lanham	Bowie
Upper Marlboro	Bristol

Note: If you order your local NAPP aerial photographs and want to use them in this lesson. One of the best ways is to go to a copier company and have them make copies of each photo that increases the size from 9-inch to 12-inch copies. Then have the copies laminated. These will be very durable and an easily used classroom resources.

- Topographic maps:

Lanham DRG	Bowie DRG
Upper Marlboro DRG	Bristol DRG

- Other ancillary data or maps (not provided for download)
- More detailed road maps (not provided for download)

- Other historical aerial photographs, especially from near the time of the earlier satellite image used to create the ΔNDVI (not provided for download)
- Color printer
- Paper

Preparation

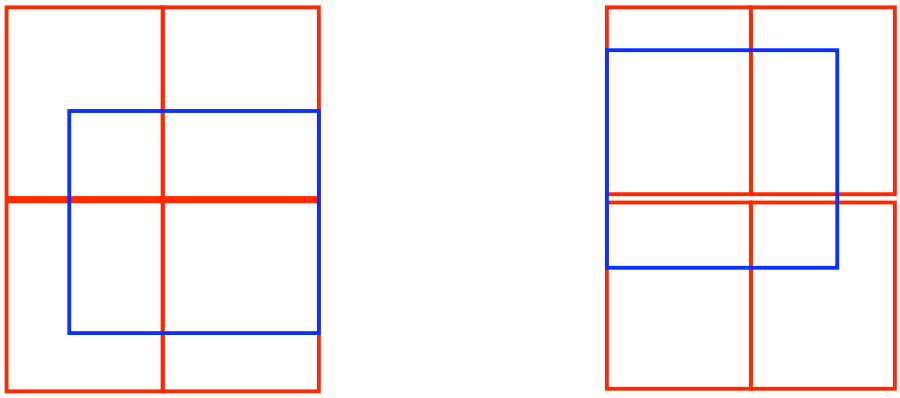
Prince George's Downloadable Data

- Download all files from the Materials and Tools section. Save the NAPP aerial photographs onto the hard drive or server for the students. Print the Landsat color composite images and NDVI images. Then title each of them. If the student groups (3-4 students per group) do not have access to a computer for this lesson, then print out each of the NAPP aerial photographs sub sections. The resolution of these files will be greatly decreased, however they will still be able to interpret many of the major features. The quality of the printer does matter here. Try and print these files on the best available printer. The higher the dots per inch or dpi the better the resolution of the printed aerial photograph. If you are going to need 10 copies of each of these photos, it is better to print each photocopy rather than print one and copy the rest. The copier reduces the quality substantially. For the best quality open the NAPP aerial photographs with either a image processing software package (Photoshop or photo editor) or the web browser (Netscape or Internet Explorer)

Local Data

- Order the NAPP Aerial photographs that covers the entire Landsat image area (most recent) from the USGS from the web site PhotoFinder**.** Make sure that you do this with enough lead-time prior to the class time because it takes 3-6 weeks to obtain them. You may want to purchase earlier aerial photographs to see the differences. (Landsat satellite coverage is from 1972 to the present.) Using the NAPP Aerial photographs to conduct remote sensing classroom activities is an invaluable resource. They make the satellite images much more familiar to the students. When you order the aerial photographs make sure to order the 9"x9" versions or making copies on a copier of the larger 18"x18" photographs can be expensive and difficult. Most copier companies can reduce the photographs down to a smaller and more useable size, but the quality is degraded.

  The student groups that will analyze the ΔNDVI image will only analyze a section of the entire image. The sections will be determined by the way your schools satellite image sits inside the quadrants established by the United States Geologic Survey, USGS.



Red box represents the aerial photograph and topographic map coverage

Blue box represents the satellite image coverage area

VCD Figure 3. The above set of images illustrates how several aerial photographs usually cover a 512x512 pixel Landsat satellite image. If the satellite image covers a large area the number of aerial photographs required will increase.

- Order Topographic maps that cover the entire Landsat image area from the USGS from the web site MapFinder. Most likely you will need to order 4 maps to cover your area. Some of the topographic maps have been digitized as Digital Raster Graphics (DRG) and can be viewed on a computer using various software programs. DRG's are available from the GIS Data Depot web site.
- Other ancillary data or maps
  - The students, parents and school community can collect the ancillary data. The hidden resources in your local schools community can be tremendous. As soon as you announce the project to the school and local community, either in person or by letter, you will be surprised at the enormity of available data that can be found to support the unit. Environmental engineering companies have these data sets that they can usually donate to the school. Departments of transportation and the environment also can usually provide the school with some of the data that you and your students could use to complete the unit.

- **Intermediate:** Create the ΔNDVI image and the NDVI images for both a current and past time using the NDVI and ΔNDVI calculation lessons. The students can very well accomplish these tasks. Once the ΔNDVI image is created you can use the ΔNDVI image worksheet template to make the handout for the students.

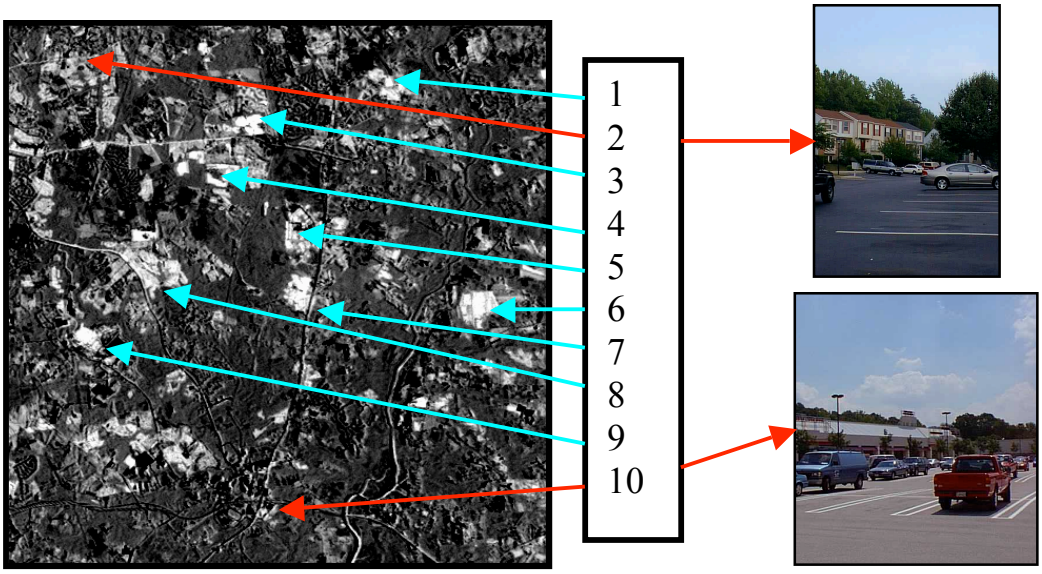
Materials:

- Landsat ΔNDVI images on worksheet. (If you are using your own local data then simply edit the RTF version of this lesson. Copy your ΔNDVI images from MultiSpec and replace the ΔNDVI images of Prince George's Maryland currently on the worksheet)

- Landsat ΔNDVI images on a Transparency
- Transparencies that are copier safe
- Aerial photograph of the same area
- Topographic map of the same area
- Student worksheet
- 12 inch Rulers- enough for one per student
- Overhead Projector
- Permanent Marker, ultra fine point
- Sets of aerial photograph and topographic map quadrants (they will be using similar areas.) One set per student group of 3-4 students is recommended.

Procedure

- Review with the students what the ΔNDVI image is, how it is created and how to read the image. The basics of the ΔNDVI image are straightforward and should not take long for them to understand, given the previous Landsat satellite work that they have completed.



VCD Figure 4. The above figure shows two areas with high pixel values and photos of the results of land cover change.

- Display the a transparency of the ΔNDVI image on the overhead projector to show the all the areas of change (white.)
- Then either directly on the transparency or on a cover transparency sheet, number all the white areas that show vegetative change. You can start from the upper left corner and move across to the right and then proceed to the bottom of the image in this manner. This will create a master list of all areas of change. This is necessary because each student or student group will be working with a subset of the entire master list.

VCD Figure 5. Students creating the master list of their change areas

- Group the students into groups of 3-4 students. Give each student group one area of the ΔNDVI image to identify and the corresponding aerial photograph and topographic map. See VCD Figure 3.
- Ask the students.
  What do you think the majority of positive values (white) areas are on the ΔNDVI image below?" Have the students record their predictions on the worksheet.
- Have the students identify the features that correspond to the high ΔNDVI values using the aerial photograph and ancillary data to aid their interpretation. They will enter their findings on the student worksheet, referencing each site by its master list number.
  - In each of the groups, have student's reach a consensus on their findings. Encourage group members to explain their reasoning and support their findings with data.

VCD Figure 6. Students identifying change areas.

VCD Figure 7. Students using ancillary data to identify change areas.

- When the groups have concluded the identification and interpretation, have a member of each group report their results to the class. Encourage students to discuss the rational for their interpretations. Since some groups will be studying the same areas, some groups will have different interpretations for the same master list number site. Have the groups that disagree on a sites interpretation work out where the error has occurred. Many errors are possible. The most likely one will be a misidentification due to not looking at the correct place on the aerial photograph when identifying a ΔNDVI high value area.

Note: Since one of the main goals of this project is to look for urban sprawl and quantify the growth of development while also determining the rate of natural vegetative land cover loss, some errors are possible. Farmland that was actively growing crops in the earlier satellite image and have barren soil in the latter image will have a high or positive ΔNDVI value. On the ΔNDVI satellite image this farmland high ΔNDVI value looks similar to areas that have a high ΔNDVI value due to urban sprawl. These areas add an interesting dimension to the discussions about what our results mean and what we as a group of scientist/interpreters can explain using this data.

There will most likely be a few areas that the students will be unable to identify using aerial photographs or other ancillary data.

- *Prince George's Data:* Since driving to the areas that cannot be identified is not possible refer to the Ground Validation web page. This web page has a number of sites all over the ΔNDVI satellite image area that have ground photographs associated with a image. If the area that students are having difficulty identifying is located on the image then click on the link and see the type of land cover.
- *Local Data:* Driving to those areas when the class ground validates the image can identify these areas. Sometimes you might be able to find aerial photographs from local sources that may help you identify the area.
    - When the master list is created ground validation is a good idea. (**Ground Validation:** information collected at the same site that a remote sensing system collects the data. Ground validation data are used to interpret, accuracy assessment and calibrate remotely sensed observations. In this case when students visit a site that they determined to be an area of urban sprawl and it is confirmed, then they know that the accuracy of their assessment.) If you have the time to take field trips to a group of randomly selected areas to confirm the student's interpretations. They can also discuss the value and role sample size plays in the scientific endeavor.

Have the students respond to the following questions.

- What does the pattern of development tell us about the how the community is changing?
- Can you think of any animals and plants that are either being helped or harmed by the continued changes in the area?
- What other data sets would help you asses risks associated with present land use? Would you want to look at a satellite image that showed the changes in vegetation for a longer time scale? What is the oldest satellite image that we could use? What is the oldest aerial photograph we could use? What is the oldest map we could use?
- What other experiments would you like to conduct?

ΔNDVI IMAGE WORKSHEET

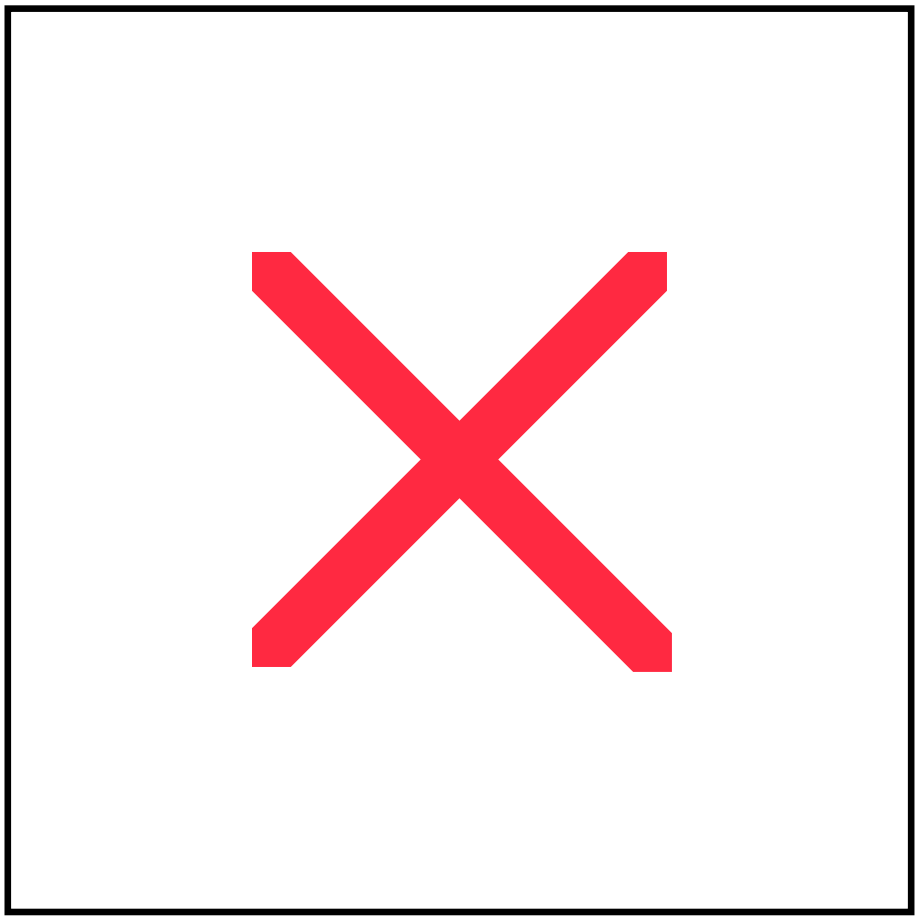
Name: _____

What do you think the majority of positive values (white) areas are on the ΔNDVI image below?

_____

_____

_____



LIST OF MAJOR GEOGRAPHIC FEATURES

Roads, rivers, urban centers

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

- Label all the major geographic or man-made features (rivers, roads and easily identified structures)
- Draw on the ΔNDVI image both the map and aerial photograph sub-areas coverage.
- Using the numbers on the image projected on the overhead identify all the high value pixel areas on the above ΔNDVI image. You only need to identify the area covered by your aerial photograph and topographic map sub area.

#___	#___	#___
#___	#___	#___
#___	#___	#___
#___	#___	#___

STUDENT WORKSHEET:
WHAT THE ΔNDVI DATA MEANS

Name _____

1. Do you think the arguments that we based our conclusions on about how our local community has changed are based on very small samples of data and or samples for which there is no control sample?

2. How do you think we could improve the way we collected this information in a way that we could actually and realistically conduct with the amount of time and money we can use?

3. Looking at your ΔNDVI_satellite image could you tell what everything on the image was? Why or why not?

4. Did you find that there might be more than one good way to interpret a satellite image? How did you interpret your quadrant of the ΔNDVI image?

5. Know that hypotheses are valuable, even if they turn out not to be true, what was your hypothesis and how did it compare to your observations of the ΔNDVI

image? Rewrite your hypothesis here:

_____

_____

_____

Your answer:

6. How did your hypothesis compare to the classes observations? Explain the differences and similarities.

7. Of all the areas that showed change on the ΔNDVI image what were the range of data that we can use to support our conclusions about growth in our area? What was the ratio of agriculture land the showed up as vegetative loss and the amount of land that actually lost vegetative land cover? _____**:**_____. Explain how you came up with this ratio.